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CONNECTION MACHINE APPLICATIONS

The Connection Machine® system's combination of power and flexibility at the data level make it appropriate for a wide range of problems that have been difficult or impossible to solve with traditional computer technology.

The system's key advantage is that it looks at whole problems at once. Its 64,000 processors search entire databases, compute across complete visual images, and simulate complete electronic circuits simultaneously, at speeds in excess of one billion instructions per second (1,000 MIPS).

The system can adapt equally well to the data patterns of word applications, visual applications, and numerical applications. Connections between processors are dynamic, changing as needed to match the problem. Data formats are dynamic as well, from one bit per word to thousands of bits per word, depending on the needs of the problem.

This combination of processing power and data flexibility makes the Connection Machine system ideal for problems with large and complex data structures. As the following examples show, these problems exist in many categories of applications.

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Example Applications: Words

Retrieval of unstructured text is one of the most difficult applications in word and language computing, and the Connection Machine system is revolutionizing the field of unstructured text retrieval. In an application where new users typically require a full day of training, the Connection Machine Document Retrieval System requires 10 minutes of training. Instead of requiring a staff of indexers to categorize incoming text, the system performs this function automatically. Where conventional systems often fail to deliver even 20 percent of the documents the user really needs to see, the Connection Machine system is achieving recall rates of 80 percent and more.

The key to this application is the program's whole document search algorithm. No intricate "Boolean expressions" are needed to refine a search. Once one or two documents are found, the user simply points to them and instructs the system to "find all the other documents on the same subject." The system extracts all the important, content-bearing terms from the example and compares them to other whole documents.

It took the combination of artificial intelligence and parallel processing technologies to solve this problem. Artificial intelligence algorithms allow the important, content-bearing terms to be extracted from documents automatically. They also allow these terms to be weighted

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according to their actual importance, so the search is accurately focused. Parallel processing allows these terms to be compared to the contents of tens of thousands of other documents in a fraction of a second. This is because the system automatically assigns an individual processor to each document, allowing the system to search a whole database at once. The benefit to users is immediate: they ask their questions in a more natural way and they get more focused and complete answers faster than ever before.

Example Applications: Images

The Connection Machine system is a perfect match for a wide range of image processing applications. For example, it dramatically increases the speed of visual information processing, frequently at rates 1,000 times as fast as conventional computers.

Image display is critical to applications where complex information must be digested readily by a human expert. As Professor Nicholas Negroponte, Director of the M.I.T. Media Arts Laboratory and an early Connection Machine customer, notes, "We are developing a very fast way to produce holograms from computer images in parallel. This is very important for medicine. We know from tests that doctors can find an anomaly in a true 3-D image much more effectively than when they use current display techniques, and holograms can give that true 3-D representation using data from CAT scanners and NMR devices."

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The Connection Machine system is also being used to process huge volumes of incoming images. In a mapping application, contour maps are computed and displayed automatically from two overhead images taken from slightly different angles. Because it looks at the whole problem at once, the Connection Machine system is able to produce contour maps at a rate of 7,000 per hour, compared to 15 per hour on a conventional machine.

Example Applications: Numbers

Numeric applications provide some of the most challenging examples of unstructured data. To accurately capture physical reality, mathematical models must often be non-uniform, more dense in one area and less dense in another. As Professor Oliver McBryan of the Courant Institute notes, "Problems such as those from structural analysis or from vortex simulations, where complex and irregular communications are required between distant processors, will benefit most from the high connectivity of the Connection Machine communications network."

VLSI simulation is another example of a numeric problem with complex and irregular communications. "Users of conventional computers rarely try to simulate more than 50 to 500 transistors at a detailed level," notes Rolf D. Fiebrich, director of the design automation group at Thinking Machines. The Connection Machine system is performing full, detailed simulations on circuits as

large as 8,000 transistors, with results available in 15 minutes or less.

Aggregate Behavior

Powerful though they are, words, images, and numbers are simply abstractions of the world around us. They simplify information and behavior that are too complicated to deal with directly. Now, with the Connection Machine system, users are reaching and modeling that behavior directly.

Fluid dynamics simulation is an excellent example. Computer models of fluids form the basis of modern weather forecasting, airplane design, automobile streamlining, and ship-hull contouring. While traditional simulations must employ complicated and imperfect mathematical formulas, the Connection Machine system models the movement and jostling of individual molecule groups directly. As billions of individual interactions occur, the fluid behavior emerges.

Moreover, because the Connection Machine system makes fluid simulation an interactive process, a user can now alter and model an object in minutes instead of hours.

The Future

The Connection Machine system's ability to operate on words, images, and numbers offers, for the first time, the ability to

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utilize all three processing modes in a single application. This means that users performing numerical simulations will be able to draw on knowledge bases of unstructured information and display their results in more sophisticated visual images. It makes possible image processing applications that will incorporate reasoning capabilities. In short, a whole new level of applications capability has been opened, and it is this capability that will form the basis of world leadership in the race to create the next generation of computer technology.

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